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Influences of Urea and Za Fertilizers to Soil Chemical Properties, N Uptake and Sugarcane Growth in Ultisols Seputih Mataram, Lampung

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ABSTRACT

Nitrogen fertilizer efficiency besides being influenced by soil type is also influenced by the type of fertilizer as the N source. The objective of this research was to find out the influences of Urea and ZA fertilizers to soil chemical properties, N uptake and sugarcane growth in Seputih Mataram Ultisols in Lampung.The experiment was conducted in a completely randomized design in 2 factors and 3 blocks for repetitions. The first factor was the sugarcane varieties; TC-09 (V1) variety and TC-15 (V2) sugarcane variety. The second factor was fertilizer doses and combinations in 7 levels: 0 kg N ha^{-1} or without N fertilizer (N0); 100% of urea fertilizer from total of standard dosage of SGC (151 kgs of N ha-1), which is 328 kg Urea ha^{-1} (N1); 86% urea and 14 % ZA or 283 kg urea ha^{-1} and 100 kg ZA ha^{-1} (N2); 75 % urea and 25 % ZA or 246 kg urea ha^{-1} and 100 kg ZA ha^{-1} (N3); 50 % urea and 50 % ZA or 164 kg urea ha^{-1} and 360 kg ZA ha^{-1} (N4); 25 % urea and 75 % ZA or 82 kg urea ha^{-1} and 539 kg ZA ha^{-1} (N5); and 100 % ZA fertilizer of 719 kg ZA ha^{-1} (N6). This results showed that Urea at the dosage of 328 without ZA is the most effective and economist combination to increase the weight of sugarcaneper hectare, N uptake of plants, and N efficiency uptake of plants. Additional dosage of ZA decreased the soil pH. The study also showed the weight and amount of population per hectare of TC 15 variety are higher than TC 09 variety

Keywords: Urea, ZA, Ultisols, N Uptake.

INTRODUCTION

Sugarcane productivity in Indonesia for recent years has decreased and it was shown by the decreasing sugarcane production and achieved yield. Productivity is determined by the genetics and environmental factors, the land processing, fertilizing, plant maintenance, plant protection, timely harvesting, and timely milling are environmental improvement efforts. In one side, there are particular varieties requiring special treatment and environment to be able express their genetic capabilities. In another side, special environment requires special varieties called local superior varieties. These genetic and environment factors need to address in the effort of productivity improvements.

Ultisol is one of soil type in Indonesia with wide distribution which reaches 45,794,000 ha or approximately 25% from total of Indonesia land width (Subagyo *et al.*, 2004). Ultisol can develop from its soil parent material from acidic to alkaline. However, most of its soil parent material is acidic rock sediment. PT. Gula Putih Mataram is located in the dry land area with ultisol soil type. Red yellowish ultisol or podzolic soils (based on soil classification in the Dudal Doepraptohardjo system (1956–1961)) are less fertile soils, but they can be used as potential agricultural field, provided that the climate is supportive and management is conducted by paying attention to existing problems. This soil has low soil nutrients, acidic reaction, and high level of Al, so that it can be toxic for plants and cause P fixation. A very acidic soil condition can cause soil to lose its cations exchange ability and its ability to store soil cations nutrient in the forms that are able to be exchanged by positive charge developments. This study used TC-09 and TC-15 variety because those two varieties are major varieties in PT Gula Puih Mataram.

Proper urea and ZA dose combination administration is expected to be able to improve the soil chemical properties (by providing soil nutrients for the plants)

and to accelerate better sugarcane growth (through fertilizing efficiency). The objective of this research was to find out the effect of varieties, application of urea and ZA fertilizers to sugarcane growth, and to find out the rate of fertilizing efficiency which combines varieties, urea and ZA fertilizers.

MATERIALS AND METHODS

This research was conducted from June to December 2016 in sugarcane plantation area of PT. Gula Putih Mataram, in block BS II/3, plot 24BS13, located in Seputih Mataram sub district, Middle Lampung district, Lampung province. During that periods, average of rain fall in the area was 2500–3000 mm/year. The materials consisted of sugarcane germs of TC-09 and TC-15 varieties, urea and ZA fertilizers. Equipment to use were tractor and its implementation to process land, and other supporting devices such as stationaries, scale, and oven.

The experiment was conducted in a completely randomized design in 2 factors and 3 blocks for replication. The first factor was the sugarcane varieties; TC-09 (V1) and TC-15 (V2) sugarcane varieties. The second factor was fertilizer doses and combinations in 7 levels: 0 kg N ha^{-1} or without N fertilizer (N0); 100% of urea fertilizer from total of standard dosage of SGC (151 kgs of N/ha), which is 328 kg Urea ha^{-1} (N1); 86% urea and 14% ZA or 283 kg urea ha^{-1} and 100 kg ZA ha^{-1} (N2); 75% urea and 25% ZA or 246 kg urea ha^{-1} and 100 kg ZA/ha (N3); 50% urea and 50% ZA or 164 kg urea ha^{-1} and 360 kg ZA ha^{-1} (N4); 25% urea and 75% ZA or 82 kg urea ha^{-1} and 539 kg ZA ha^{-1} (N5); and 100% ZA fertilizer of 719 kg ZA ha^{-1} (N6). The total of treatment combinations were 2×7= 14 treatments. Each treatment was repeated 3 times, so that there were 3 x 14 = 42 plots of experiment. 100 kg of TSP and 280 kg of KCl were added to every plots.

The soil samples were analyzed to find out soil conditions in the beginning of research. The land was then processed according to standards in sugarcane cultivation. Urea fertilizer was applied based on the determined doses at 1.5 months after planted

The data of the soil chemical properties in this research included soil organic-C content, pH H_2O, N total, C/N ratio, NH_4^+, and NO_3^- at 6 months after planting (MAP). Observations to the sugarcane plant included population, plant height, leaf width, wet and dry biomass, sugarcane weight, Nitrogen (N) content in the plant, N uptake and N uptake efficiency at 6 months after planting (MAP), and sugarcane weight at 10 MAP. Collected data was analyzed by using analysis of variance (ANOVA) and Duncan Multiple Range Test (DMRT) at 5% significance level. The determination of optimal N uptake and N uptake efficiency was conducted by using regression analysis, while the correlations between observed variables were determined with correlation analysis.

RESULT AND DISCUSSION

Soil Chemical Analysis

1. Initial Soil Chemical Properties

Analysis results showed that the initial soil pH at the research location was acidic with values of 4.98 at 0–20 cm soil depth and 4.52 at 20–40 cm soil depth. Soil pH is very important in determining microorganism activity and domination such as nitrification, denitrification, decomposition, and organic compound synthesis which are influential to the soil nutrient availability. Macro nutrient elements contained in the soil were very low unless available P (N-total 0.08%, available-P 82.67 ppm and exchangeable K 0.35 me 100 g soil-1). High value of available P is caused by TSP fertilizing every year. Organic material content was very low with low decomposition rate which indicated that without organic material administration C (carbon) element would be more rapidly depleted.

2. Sugarcane growth

The results showed that the combination of urea and ZA fertilizers did not influence significantly sugarcane growth parameters (population, leaf width, plant height, and ton/ha sugarcane weight) and there was no interaction between fertilizer dose combinations to sugarcane varieties. Environment has the most dominant influence for the plant growth sustainability. When plant shooting process is going on, it needs big amount of water, so that if the rainfall rate is sufficient, then it will support the plant shooting process properly. Dillewijn (1952) states that plant stem numbers will increase along with N fertilizer addition up to particular doses. The leaf width which is also called as leaf area index (LAI) is an agronomy parameter that has an important role in determining the plant quality. Leaf width parameter determines the extent of plant ability in using solar energy for plant assimilation necessity.

N availability amount becomes the most dominant factor which influences the plant height. In addition, this factor influences the plant height include environmental factors such as topography and rainfall rate (2500–3000 mm/year). The role of water is very big in the process of stem lengthening. Even though fertilizer has been maximum in the initial growth, without suf-

Table 1. Soil chemical properties in the research location in 0–20 cm and 20–40 cm soil depths.

Soil parameters	0–20 cm	Grade	20–40 cm	Grade
Texture				
Sand (%)	68	Clay with sand	66	Clay with sand
Dust (%)	5		6	
Clay (%)	26		28	
pH				
pH H_2O	4.98	Acidic	4.52	Acidic
pH KCl	4.59	-	4.17	-
Organic materials				
C-Organic (%)	0.89	Very low	0.35	Very low
N (%)	0.08	Very low	0.06	Very low
C/N	11.16	Moderate	6.13	Low
Extract of Bray 1				
Available P_2O_5 (ppm P)	82.67	Very high	15.93	Very high
Extract of NH_4-Acetate 1N, pH 7				
Ca (me 100 g $soil^{-1}$)	0.09	Very low	0.04	Very low
Mg (me 100g $soil^{-1}$)	1.34	Moderate	0.88	Low
K (me 100g $soil^{-1}$)	0.35	Low	0.24	Low

*Criteria based on the Soil Research Office (2009)

Table 2. Population per hectare, leaf width, plant height, and sugarcane weight per hectare in varying combination of urea and ZA fertilizers at 6 MAP and 10 MAP.

Treatments	Population per ha at 6 MAP	Leaf width (cm2) at 6 MAP	Plant height (cm) at 10 MAP	Sugarcane weight (ton ha^{-1}) at 10 MAP
Type of variety:				
Variety TC-09 (V1)	105.23 a	688.60 a	204.33 b	97.33a
Variety TC-15 (V2)	107.67 a	671.71 a	219.71 a	101.62 a
Fertilizer combination (N)				
Urea 0, ZA 0 (N0)	98.67 b	647.06 a	192.83 b	97.90a
Urea 328, ZA 0 (N1)	107.88 a	683.92 a	215.66 a	98.89 a
Urea 283, ZA 100 (N2)	104.72 ab	708.70 a	212.16 a	99.15 a
Urea 246, ZA 180 (N3)	107.18 a	624.71 a	217.50 a	103.38 a
Urea 164, ZA 360 (N4)	107.21 a	694.26 a	214.83 a	94.90 a
Urea 82, ZA 539 (N5)	108.50 a	724.58 a	211.83 a	104.02 a
Urea 0, ZA 719 (N6)	111.01 a	676.85 a	219.33 a	99.063 a
Interaction	(-)	(-)	(-)	(-)

Notes : Numbers in a column followed by the same letter do not differ significantly according to DMRT at 5% trust level. Mark (-) indicates that there is no interaction.

ficient water support the lengthening will be slowing. These results prove that sugarcane is not responsive to nitrogen fertilizing (Kuntohartono, 1987).

Analysis results showed that the combination of urea and ZA fertilizers did not influence significantly dry biomass and there was no interaction between combined fertilizer doses and sugarcane varieties. In that table showed that TC-15 variety shows weight of sugarcane per hectare higher than TC-09 variety. The study result also showed that Combination at dosage of Urea 328 kg ha^{-1} + 0 kg ZA ha^{-1} shows the highest weight per hectare.The objective of fresh and dry root weighing was to find out difference between weight value to find out the extent the sugarcane stored water and soil nutrient uptakes in the root. High water content can be results of plant division and good development, so that the plant is able to absorb water and stores soil nutrients properly which

Table 3. Sugarcane dry biomass at 6 MAP in varying combinations of urea and ZA fertilizers.

Treatments	Sugarcane dry biomass at 6 MAP (ton ha^{-1})			
	Stem	Green leaf	Dry leaf	Root
Type of variety:				
Variety TC-0 (V1)	2.59 a	1.03 a	1.29 a	0.24 a
Variety TC-15 (V2)	2.76 a	1.01 a	1.13 a	0.30 a
Fertilizer combination (N)				
Urea 0, ZA 0 (N0)	2.21 b	0.86b	1.05 a	0.31 a
Urea 328, ZA 0 (N1)	2.73 ab	1.04 ab	1.21 a	0.28 a
Urea 283, ZA 100 (N2)	2.40 ab	0.95ab	1.22 a	0.23 a
Urea 246, ZA 180 (N3)	2.99 a	1.05 ab	1.43 a	0.26 a
Urea 164, ZA 360 (N4)	3.00 a	1.18 a	1.44 a	0.28 a
Urea 82, ZA 539 (N5)	2.85 ab	1.07 ab	1.02 a	0.26 a
Urea 0, ZA 719 (N6)	2.54 ab	1.00ab	1.11 a	0.28 a
Interaction	(-)	(-)	(-)	(-)

Notes : Numbers in a column followed by the same letter do not differ significantly according to DMRT at 5% trust level. Mark (-) indicates that there is no interaction.

Table 4. Soil chemical properties in the research location after treatments (at 6 MAP)

Treatments	pH H_2O content	Organic-C content	Total-N (%)	Available-P (ppm)	Available-P (ppm)
Type of variety:					
Variety TC-09 (V1)	5.05 a	0.90 a	0.07 a	83.99 a	0.092 a
Variety TC-15 (V2)	4.82 a	0.90 a	0.07 a	77.35 a	0.090 a
Fertilizer combination (N)					
Urea 0, ZA 0 (N0)	5.09 a	0.92 a	0.07 a	84.39 a	0.065 a
Urea 328, ZA 0 (N1)	5.00 a	0.90 a	0.07 a	83.93 a	0.070 a
Urea 283, ZA 100 (N2)	5.02 a	0.88 a	0.07 a	77.82 a	0.091 a
Urea 246, ZA 180 (N3)	5.04 a	0.89 a	0.08 a	75.52 a	0.081 a
Urea 164, ZA 360 (N4)	4.86 a	0.90 a	0.06 a	76.04 a	0.095 a
Urea 82, ZA 539 (N5)	4.77 a	0.92 a	0.07 a	84.13 a	0.106 a
Urea 0, ZA 719 (N6)	4.77 a	0.91 a	0.07 a	87.90 a	0.096 a
Interaction	(-)	(-)	(-)	(-)	(-)

Notes : Numbers in a column followed by the same letter do not differ significantly according to DMRT at 5% trust level. Mark (-) indicates that there is no interaction.

are then translocated to the plant canopy (Sarjadi, 1970).

3. Soil Chemical and Plant Properties

Soil chemical properties after treatments

Analysis results showed that the administration of urea and ZA fertilizers combination did not influence significantly the soil chemical properties (pH H_2O, organic-C, total-N, available P, and available K) and there was no interaction between fertilizer dose combinations and sugarcane varieties.

In general the reduced pH was suspected to be caused by continuous N administration, especially with ZA fertilizer, could also reduce soil pH where in 0-20 cm soil depths, the influence of N fertilizer dose increase seemed to be more significant to reduced soil pH. Decreasing pH in ZA fertilizing is caused by ZA has sulphate ion (SO_4^-). Even ZA fertilizing increased soil acidity, ZA still can be used in acidic soil because ZA not only supplies Nitrogen (N) but also Sulfur (S) in the form of Sulphate (SO_4). The average of organic-C content in various treatment combinations belonged to low category, and it was suspected to be caused by microorganism activity level in decomposing organic materials. This was because the organic materials decomposition process had been long going on. Treatments of this study has no influence to organic C content. Total-N content

Table 5. Soil chemical properties in the research location after treatments (at 6 MAP)

Treatments	NH_4^+ (%)	NO_3^- (%)
Type of variety:		
Variety TC-09 (V1)	6.85 a	13.84 a
Variety TC-15 (V2)	7.28 a	13.95 a
Fertilizer combination (N)		
Urea 0, ZA 0 (N0)	7.81 a	7.20 a
Urea 328, ZA 0 (N1)	6.57 a	13.69 a
Urea 283, ZA 100 (N2)	6.74 a	12.52 a
Urea 246, ZA 180 (N3)	6.89 a	13.18 a
Urea 164, ZA 360 (N4)	7.36 a	19.12 a
Urea 82, ZA 539 (N5)	7.27 a	14.65 a
Urea 0, ZA 719 (N6)	6.83 a	16.91 a
Interaction	(-)	(-)

Notes : Numbers in a column followed by the same letter do not differ significantly according to DMRT at 5% trust level. Mark (-) indicates that there is no interaction.

in soil is the number of N left in the soil after being used by the plant (Marschaner,1986). The analysis results showed that the application of dose combination of urea and ZA fertilizers did not influence significantly the NO_3 content and there was no interaction between fertilizer dose combinations and sugarcane varieties.

ZA fertilizer dose increase influences NO_3^- content in the soil. This was proven in the urea and ZA fertilizers application with doses of 328 kg/ha and 0 kg ha^{-1} respectively, where NO_3^- was lower compared to administration of Urea and ZA fertilizers with doses of 164 kg ha^{-1} and 360 kg ha^{-1} respectively. This is understandable because NO_3^- source comes from ammonium fertilizer applicated ed to the soil. The formation of NO_3^- from ammonium needs oxygen, and it occurs in the soil with good aeration. The NH_4^+ contents in varying combination of treatments were lower than NO_3^- because the soil samples came from areas close to rooting center. There are N form differences taken from different places, where NO_3^- is mostly absorbed close to rooting zones and NH_4^+ is mostly absorbed at the tips of the roots. Because the soil reacts properly, most of NH_4^+ is oxidized into NO_3^- (Schwab and Perace, 1992).

The analysis results showed that the application of urea and ZA dose combinations did not influence significantly the total-N content of sugarcane and there was no interaction between fertilizer dose

Table 6. Soil chemical properties in the research location after treatments (at 6 MAP)

Treatments	N content of sugarcane at 6 MAP (%)				
	Stem	Green leaf	Dry leaf	Root	Average of canopy
Type of variety:					
Variety TC-0 (V1)	1.48 a	1.03 a	1.29 a	0.24 a	2.4 a
Variety TC-15 (V2)	1.48 a	1.01 a	1.13 a	0.30 a	2.4 a
Fertilizer combination (N)					
Urea 0, ZA 0 (N0)	1.44 a	0.86b	1.05 a	0.31 a	2.40 a
Urea 328, ZA 0 (N1)	2.73 ab	1.04 ab	1.21 a	0.28 a	2.48 a
Urea 283, ZA 100 (N2)	2.40 ab	0.95ab	1.22 a	0.23 a	2.50 a
Urea 246, ZA 180 (N3)	2.99 a	1.05 ab	1.43 a	0.26 a	2.44 a
Urea 164, ZA 360 (N4)	3.00 a	1.18 a	1.44 a	0.28 a	2.50 a
Urea 82, ZA 539 (N5)	2.85 ab	1.07 ab	1.02 a	0.26 a	2.49 a
Urea 0, ZA 719 (N6)	2.54 ab	1.00ab	1.11 a	0.28 a	2.45 a
Interaction	(-)	(-)	(-)	(-)	(-)

Notes : Numbers in a column followed by the same letter do not differ significantly according to DMRT at 5% trust level. Mark (-) indicates that there is no interaction.

Table 7. The plant N uptake and uptake efficiency in varying combinations of urea and ZA fertilizers application

Treatments	Root N uptake	Plant N uptake	N root uptake efficiency	Plant N uptake efficiency
Type of variety:				
Variety TC-09 (V1)	7.05 a	145.53 a	0.26 a	7.02 a
Variety TC-15 (V2)	6.89 a	132.93 b	0.15 a	6.75 a
Fertilizer combination (N)				
Urea 0, ZA 0 (N0)	5.77 c	104.73 c	0.00 c	0.00 e
Urea 328, ZA 0 (N1)	7.25 ab	150.59 b	0.38 a	13.14 a
Urea 283, ZA 100 (N2)	6.85 b	126.65 b	0.22 b	5.00 cd
Urea 246, ZA 180 (N3)	6.71 b	149.99 a	0.17 b	9.98 ab
Urea 164, ZA 360 (N4)	7.24 ab	153.82 a	0.24 ab	8.84 bc
Urea 82, ZA 539 (N5)	6.98 ab	142.61 ab	0.16 b	5.65 cd
Urea 0, ZA 719 (N6)	7.798 a	139.4 ab	0.25 ab	4.44 d
Interaction	(-)	(-)	(-)	(-)

Notes : Numbers in a column followed by the same letter do not differ significantly according to DMRT at 5% trust level. Mark (-) indicates that there is no interaction.

combinations and sugarcane varieties. There are interaction between combination Urea and ZA fertilizing to sugarcane varieties in

Total-N in plant tissues is the accumulated amount of N in the tissues because of plant absorption. Absorbed N content is used for nutrition for morphological and physiological growth (photosynthesis). Nitrogen element is required by sugarcane in the most relative amount. The higher the total-N content in a plant tissues is, then the better it is. This is because N is more efficient to be used by the plant. Clement (1980) states that the N element administration will increase N level at all plant parts especially in leaf tissues.

4. The Plant N Uptake and Uptake Efficiency

The analysis results showed thatthe combination of urea and ZA fertilizers application did not influence significantly the N uptake and N-uptake efficiency of sugarcane. There was interaction between fertilizer dose combinations and sugarcane varieties in root N-uptake and root n-uptake efficiency.

Maximum N uptake progress occurs at 3–6 months after planting (MAP) when the shoot grows and stem lengthens up to maximum vegetative period. After that, soil N availability should be increasingly lower in order sugar deposit progress in stem to occur (Tisdale *et al*., 1985 *cit*. Gonggo *et al*., 2006). These statements suggest that the N uptake analysis will be best conducted at the maximum sugarcane vegetative period at 6 MAP.

CONCLUSIONS

Additional of ZA's dosage causes decreassing of soil pH. Weight and amount of population per hectare of TC 15 variety are higher than TC 09 variety. There is no relation between urea and ZA combination and sugarcane variety to sugarcane growth (plant's height, leaf's area, wet and dry biomass, and sugarcane weight). Combination between Urea and ZA at the dosage of 328 kgs Urea ha^{-1} + 0 kg ZA ha^{-1} is the most effective and economist combination to increase the weight of sugarcane per hectare, N uptake of plants, and efficiency of N uptake of plants.

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